Knowledge mapping of office workspace: A scientometric review of studies

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Abstract

Purpose

Office workspace is more than a place but one of the essential resources in business organizations. In recent years, research in office workspace management has become an increasingly important scholarly focus. However, there is a dearth of bibliometric studies to date on the subject. This study therefore explores scientometric analysis of office workspace field.

Design/methodology/approach

Title/Abstract/Keyword search method was employed to extract related articles from 1990 to 2018. A total of 1,670 articles published in Scopus were obtained and subjected to scientometric data analysis techniques via CiteSpace software.

Findings

The results revealed the active research institutions and countries, influential authors, important journals, representative references, and research hotspots in this field.

Originality/value

This is probably the most comprehensive scientometric analysis of the office workspace field ever conducted. This study adds to the so far limited knowledge in the field and provides insights for future research.

Keywords- workspace, office, management, Scientometric, CiteSpace

Introduction

Efficient use of office workspace resources is critical in the modern competitive business era. The duo of technological advancement and globalization have not only enhanced the expansion of business sectors but they have also brought significant changes to office space usage patterns. These two influential drivers have brought about changes to the organizational structure of corporate offices (Cattell, 2002; Harris, 2015) through new working practices such as teleworking, team-work, hot-desking and flextime (Haynes, Fawcett, & Rigby, 2009; Rabianski & Gibler, 2007). Laing, Craig, and White (2011) posited that using 20th-century spaces to do 21st-century knowledge work will result in productivity losses and higher capital expenses. A significant change to the office workplace and space usage has been noticed over the last 2 decades (Harris, 2015). Recent research revealed that some technology-driven new working practices (NWPs) do exert an increasing impact on office workspace management by altering the way in which firms use space - e.g., more communal space rather than territorial offices (De Been & Beijer, 2014; Dixon, Marston, Thompson, & Elder, 2003; Harris, 2015; Miller, 2014). Such new ways of working have become increasingly a common strategy to manage expensive real estate around the world (De Bruyne & Beijer, 2015). There is a growing interest in workspace design (De Paoli, Sauer, & Ropo, 2017) which can be linked to the contemporary approach to organizing office workspace that started to evolve in the late 1980s (Strati, 2017).

In recent years, research on corporate space management has become an increasingly important scholarly focus. However, while noting the increased interest in the workspace, Yanow (2010) observed that workspace has been largely ignored in the literature, and advocated for more attention towards spatial arrangements. Moreover, there is a dearth of bibliometric studies to date on office workspace management because of the limited attention given to the need to review and analyze what has already been identified in the literature. This study aims to map publication trends and explore research hotspots on office workspace through a scientometric review of literature in order to broaden the knowledge and the depth of the development in this field. Lah, Mohammed, and Naim (2015) conducted a critical review of office workspace studies from a facilities management perspective, and they categorized the studies into space management, utilization, and efficiency, and highlighted future research directions. However, Lah et al. did not provide insights into research outputs on office space usage and management from a broader perspective. Their review was narrow in focus and hence could not capture the latest research about new developments and improvements on workspace management. De Croon, Sluiter, Kuijer, and Frings-Dresen (2005) researched the effects of different office concepts on the office employees. Their review study is also narrow on its coverage and only reviewed studies on the effects of various office dimensions (i.e. office location, office layout, and office use) on workers. Many organisations have made inefficient (and costly) decisions in space planning due to a misunderstanding of how space strategies impact on business performance over time (Dao, Langella, & Carbo, 2011; Delgado-Ceballos, Montiel, & Antolin-Lopez, 2014). This shows the importance of a research study that explores current trends in office space management. Such a study needs to utilize an interdisciplinary approach that integrates various economic sectors and regions to provide a better understanding of the development in office workspace around the world. Such an

understanding is essential if the challenges faced by those involved in office workspace planning and management are to be effectively addressed. This paper will fill this research lacuna.

Real estate sector has three main segments, namely, residential (e.g. homes), commercial (e.g. office space) and industrial (e.g. factories) which can be further categorized into various sectors (Gotham, 2006). Among them, the office sector has been the most volatile in terms of space usage and development (Renaud, 1997) because of the influence of technology and globalization (that give rise to new ways of working) on office space usage and space demand (Harris, 2015). This influence is clearly evident in the changes happening in the average space per person in offices (Gibson, 2003b). Office workspace is dynamic and receptive to occupation ratios, new ways of practice and technology changes (Miller, 2014). Hence, it is necessary to review past studies and identify current research directions in order to gain insight into future office workspace management. This study, therefore, assessed the office workspace in the commercial real estate sector. This present study is a timely scientometric review that broadly examined the productivity and quality of scholarly research contents using established indices and indicators to evaluate the office workspace. The scientometric analysis of this research domain is of great importance as it offers researchers, facility managers, research organizations, and funding agencies with an empirical measure to assess the performance of research output in this field. In addition, the analysis has a great potential to advance useful insights into the evolution of the global research on the office workspace and evaluation of research performance of the knowledge base. Following the introduction, a review of relevant literature along with the background of office workspace management is provided. The next section describes the methodology used in the study. The findings from the identified academic publications were presented and discussed in the penultimate section. The paper concludes by encapsulating the findings and stating future research directions.

Studies on office space management

The concept of office workspace was almost not in existence in medieval eras, as most people worked from home, but it changed in the 17th century when professionals began to work from offices in places like Amsterdam, London, and Paris. Hence, a clear distinction between the office as a workplace, and the home, as a place of comfort, privacy, and intimacy emerged (Rybczynski, 1986). The office is more than just a place, rather a strategic resource that enables and sustains organizations to achieve competitive advantage and maintain operational efficiency (Khamkanya, Heaney, & McGreal, 2012). The efficient use of resources, especially space, is crucial as business organizations use space to enhance their profitability (Hills & Levy, 2014). However, organizational workspace is continuously evolving and transforming even as business itself is changing. The origin of the modern office could be traced back to the middle of the nineteenth century. As a result of the industrial revolution, it triggered a significant increase in information-related problems demanding measures of control (Bradley, 2007). As businesses feel the pressure to sustain in the market, strategies such as new work practices emerged, in which workplace managers changed their role from reactive traditional focus to strategic and proactive space

management (McGregor, 2000c).

The dramatic changes that took place about alternative office strategies in the early 90s made workspace managers to imagine non-existence of physical offices in the 21st century 2000 (Madsen, 2001). At that time when companies began to redesign their office spaces to accommodate new working practices such as teamwork and teleworking, it was not certain whether it was due to a cultural revolution or just a mere cost-cutting (Meyer, 1997). Subsequently, the evolvement of new ways of working has revolutionized office space usage in terms of space downsizing with the purpose of shrinking occupancy costs and enhancing worker productivity (Tagliaro & Ciaramella, 2016). There has been a global trend characterized by less designated space and more shared space in offices (Hills & Levy, 2014). Due to this space crunch, shrinking office sizes is prominent in Europe (such as Germany, France and Switzerland) and Asia (especially, Singapore, Hong Kong, Japan, Korea and Taiwan) compared to the US where most office spaces are still above the Building Owners and Managers Association (BOMA) international density recommendation of 225 square feet per person (Knapp, Vickroy, de Bruyn, & Kwong, 2009).

Generally, space is an essential resource for the sustenance of activities in an organization. In an organizational context, space is defined as a portion of the entire facility that can be used or cannot be used for daily activities (Hassanain, 2010). Meanwhile, office workspace is vital in efficient management of an organization (Lah, Mohammed, Abdullah, & Asmoni, 2015) as a different kind of office activities will require different types of space and efficient space utilization will foster; improved productivity, higher employee satisfaction, enhanced positive image, greater flexibility and appropriate use of resources (Van Der Voordt, 2004). Hence, Best, Langston, and De Valence (2003) posited that efficient workspace management is one of the major factors which facilitate an increase in values of an organization. Also, Shiem-Shin Then (1999) revealed that an optimum functionality of workspace is good support for human resources and business processes in an organization. Obviously, optimization of the workspace can be attained through effective management of organizational space and effective planning and management of workspace will support efficiency, cost reduction, and overall success of an organization. More so, effective space planning in an organization can be achieved via a number of spatial planning approach and implementation of a comprehensive management system for efficient space management (Lindahl, 2004).

Researchers studying office workspace have agreed on two main issues affecting space management, which are space utilization and cost (Lah, Mohammed, Abdullah, et al., 2015). Effective office workspace utilization is one of the central activities under the facility management (Hinks & McNay, 1999) and reduction in the cost incurred is the major focus in good space utilization aside the support of the daily work activities (Unwin, Fecht, & Bergsman, 2008). Office workspace can either be overutilized or underutilized based on the usage and changing pattern of the working environment, thus, optimum space utilization is imperative (Gibson, 2003a). Although office space utilization in the public sector differs greatly from that of a private sector (Lah, Mohammed, Abdullah, et al., 2015), generally, most organizations have not been fully utilizing their office workspace because

majority of their employees spend lesser time in the office than the time spent outside the office (Fawcett & Rigby, 2009; McGregor, 2000a). Therefore, optimizing the use of workspace is important in order to maximize the amount of time a particular space is in use. Common strategies implemented modern workplace to improve workspace efficiency is by reducing the size of the space and introducing new working practice concept such as teleworking and blended working (Van Yperen, Rietzschel, & De Jonge, 2014). Most organization reduced the size of space per employee and consequently realized cost saving (Steiner, 2006), however, it is important to establish a balance between space reduction and employees' satisfaction (Kampschroer & Heerwagen, 2005).

An assertion by McGregor (2000b) that work will no more be a place, but an array of activities that can be practically undertaken anywhere and at any given time calls for attention on the paradigm shift that could revolutionize office space management. There has been an argument as to whether the types of workspace design such as hive, cell, den, and club (see Haynes, 2008) help or disturb the performance within an organization (Waber, Magnolfi, & Lindsay, 2014). Some studies revealed negative effects of new office workspace arrangement such as open-plan offices (Ali, Chua, & Lim, 2015; Binyaseen, 2010; Smith-Jackson & Klein, 2009) while some studies highlighted the benefits of such arrangements (Chilton & Baldry, 1997; Waber et al., 2014). However, a recent study by Gerdenitsch, Korunka, and Hertel (2018) revealed that the effects of some changes in workspaces on office workers are still far from clear. Although studies of space management from organizational perspective have taken ground, interest in organizational studies concerning the value of space management is generally lacking (Skogland & Hansen, 2017). The improper allocation of the workspace (Binyaseen, 2010) invariably affects the employee's satisfaction and productivity. As the knowledge expands rapidly in a field, it is always beneficial to do a check from time to time and retrospectively analyse the discipline itself for necessary clarity (Holsapple, 2008). For example, one may want to know the trendy topics, leading researchers, level of collaborations, influential publication outlets, the perception of journal quality, most productive institution and country etc. (Serenko, Bontis, Booker, Sadeddin, & Hardie, 2010). The present research fulfilled this by exploring the existing literature to find pathways and avenues to shape research directions for future researchers and other interested parties such as research organizations and funding agencies.

Methodology

This study adopts a descriptive research approach of scientometric analysis to explore the quantity, characteristics, and productivity of global research publications in the field of an office workspace. The descriptive scientometric approach was employed as it is capable to comprehensively engage and explore the totality of intellectual core of a scientific domain instead of focusing on its individual outputs (Sidorova, Evangelopoulos, Valacich, & Ramakrishnan, 2008). A visualization software (CiteSpace) was employed to visualize the output of the results of the analysis.

Data sources

Journal papers are a central part of scientific communication and are therefore reliable as the primary source for literature review (Brinkø, Nielsen, & Meel, 2015). Therefore, the office space-related articles published in refereed journals from 1990 to 2018 were retrieved. The search commenced from 1990 because the alternative office strategies embraced by business organizations started in the early 90s (Madsen, 2001). De Paoli et al. (2017) also revealed that studies on workspace actually started during the late 1980s. A powerful database, Scopus, containing a broader and comprehensive spectrum of journals and articles was employed for the search because of its better performance compared to other search engines such as Web of Science, Google Scholar and PubMed (Falagas, Pitsouni, Malietzis, & Pappas, 2008). Scopus is arguably the largest citation database (Jahangirian, Eldabi, Naseer, Stergioulas, & Young, 2010). In order to formulate a search statement for this review, keywords and main concepts were identified from an initial review of relevant literature materials. More so, the researchers thought of similar terms or phrases that might be used to describe the concepts of office workspace, to ensure that no relevant information is missed out. The data retrieval strategy employed for the search included the following:

(Title-abs-key ("corporate facilities*" or "office accommodation*" or "office layout*" or "corporate workplaces*" or "virtual office*" or "corporate workspaces*" or "coworking space*" or "creative office space*" or "office space*" or "corporate real estate*" or "workplace management*" or "workspace management*")) and doctype (ar or re) and pubyear > 1989 and pubyear < 2019 and (limit-to (language, "English"))

The study draws on the literature from various fields, with the aim of providing complete relevant information regarding office workspace research. Articles that described office or space in a different context other than the context of this study (e.g. computer-related) were manually eliminated from the search results. In total, 1670 articles on office workspace were obtained. As the Research Information Systems (RIS) format is the preferred format for Scopus data files, the search results were saved to a data file in RIS.

Annual publications on office workspace from 1990 to 2018

Based on the search results from Scopus, the annual trend of publications of office workspace related studies from 1990 to 2018 is presented in **Figure 1**. The total number of papers published in the studied period is 1670 with only 15 publications in 1990 escalating to 138 publications in 2017, amounting to an average yearly publication of 60 papers. This is indeed an indication of a significant increase in research interest on the subject. The trend line (represented by dotted line) in **Figure 1** indicates an increasing trend in publications which could be as a result of growing information and communication technology, which is correspondingly encouraging the adoption of new space concepts in organizations. It is expected that the upward trend of office workspace research would continue as more new ways of working are adopted to reshape organizational process and space. Moreover, the

demand for workspace is increasing worldwide as population increases (Morrison & Macky, 2017) which would apparently trigger the need for more research studies into the workspace in corporate organizations.

Please insert Figure 1 here

Analysis tool

Traditionally, researchers used scientometric analysis to analyse a country, institutional and individual-level research productivity through a scientific mapping of the literature (Manning & Barrette, 2005). Science mapping software tools are computer algorithm packages that have been specifically developed to carry out bibliometric mapping analysis, and many of these types of tools have been utilized in the scholarly community (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011). According to a recent comparative analysis of tools, three of them are widely used by the research community (including; CiteSpace, VOSviewer, and HistCite) with more attention on CiteSpace and VOSviewer than others (Pan, Yan, Cui, & Hua, 2018). However, findings from the literature showed that both CiteSpace and VOSviewer produce a similar basic structure in terms of visualization (Zhang, Zhao, & Ye, 2011). Hence, researchers can choose any of these two tools. The CiteSpace visualization analysis software (version 5.3.R4, 64 bit) was used in the present study to carry out scientometric analysis in the office workspace field. Although dataset used by the CiteSpace are sourced from different databases, its data processing algorithm is only compatible with Web of Science (WoS) database format, hence, the dataset from Scopus (RIS format) was converted by CiteSpace to WoS format prior to data processing. CiteSpace normally indicates the number of records in each RIS files being converted and the amount of total cited references found in the data files. CiteSpace software then estimates and display how many of the references have been converted successfully. In this case, 97.0% (i.e. 1620 article records) of the references were successfully converted which is more than the specified threshold for a very decent success rate of 95.0%, considering all the anomalies in the cited references (Chen, 2014). Using the same search statement, the number of articles retained (1620) was still higher than the number of articles generated by WoS. Therefore, the use of Scopus is justified for this study.

CiteSpace is a Java application that combines information visualization methods, bibliometrics, and data mining approach, for analyzing and visualizing co-citation networks (Chen, 2004). CiteSpace can be used to construct several types of knowledge networks from various entities such as cited references, collaborating authors, co-occurring keywords, and other visualized results, from bibliographic sources (Chen, Dubin, & Kim, 2014). The networks generated by CiteSpace contain the “nodes” which indicates the analyzed elements/entities, for example, author, institution, country, documents, and keywords. The size of each node reflects the publication frequency or citation count for the element being studied such that the larger node represents higher frequency or more citation counts. An aggregation of individual nodes into groups is called cluster, which

represents a distinct domain or a thematic intensity (Chen et al., 2014). Whereas, a link in a co-citation network signifies how frequently two entities (e.g. authors, documents) are cited together by other entities. Also, betweenness centrality is another important mapping result which reflects the influence of a node on the other nodes in the knowledge network. The larger the centrality of an entity, the higher the influence of the entity on other entities in the network, and more likely it is to become the key entity (Liang, Luo, & Zhong, 2018). Other properties worthy of note (especially, properties used for identifying emerging topics in a field) include highly cited landmark articles (i.e. articles with significant attractions from research community), articles with sudden increase in citations indicating strong citation bursts, and keywords with a strong surge of frequency (Chen et al., 2014). All these analyses were performed in this study to discover the core strengths, principal authors, key journals, scholarly information base, and hotspots in the field of an office workspace.

Results of analysis

Analysis of core strength

Distribution of publications by subject areas

Having filtered the publications by subject areas, the articles were associated with and distributed across various subject areas. The network produced 82 nodes and 252 links. Although the publications scattered across various sectors of economic and research boundaries, this analysis reveals the subject areas that produce more publications than others. The top 10 subject categories are summarised in **Table 1**, with the publication year of the first paper in parenthesis. A larger number of publications were identified in engineering classification. This study reveals that office workspace research is strongly dominated by engineering subjects. Construction & Building Technology is the second subject area that has embraced office workspace related research. Business & Economics occupied the third position with a frequency of 255 articles, and the first publication appeared in 1990, indicating the earliest subject area that embraced office workspace studies.

Please insert Table 1 here

Geographic distribution of research output in office workspace

This section deals with the contribution of countries to the body of knowledge in the field of an office workspace. **Figure 2** presents the network of co-authors' countries in which multiple occurrences in the same paper are counted once. The network generated 50 nodes and 147 links. Ten (10) countries with greater contributions were identified by CiteSpace. The top-ranked country with the highest number of publication is the USA, with a citation

count of 445, which is more than twice the number of articles published in the United Kingdom. The second one is the United Kingdom with a citation count of 158, while Australia and the Netherlands occupied the third position with citation counts of 74 each. The rest are; Canada, Germany, Finland, Malaysia, Singapore, and Japan with citation counts of 62, 46, 42, 31, 29, 28 respectively.

The top-ranked item by citation bursts is China with bursts of 5.21**,** spanning 2014-2018. The second is India with bursts of 4.06, spanning 2014-2018, followed by Italy in the third position with a burst strength of 3.81, spanning 2015-2018. The fourth is Lebanon with bursts of 3.58, spanning 2014-2016. The fifth is South Korea with bursts of 3.51, spanning 2013-2018. The last in this category is Nigeria with bursts of 3.48, spanning 2012-2016. In terms of betweenness centrality, the top-ranked country is the USA, with the centrality of 1.06, followed by Germany in the second position, with the centrality of 0.22. The third is Lebanon, with the centrality of 0.20 and the fourth and the fifth are the Netherlands and the United Kingdom, with the centrality of 0.19 and 0.17, respectively.

Please insert Figure 2 here

Figure 3 shows the network of institutions of authors involved in office workspace research with 143 nodes and 63 links. The size of the node label signifies the size of articles published by the respective institution. For the sake of clarity, CiteSpace generated top ten institutions based on the numbers of associated publications for each institution (see **Table 2**). There are no citation bursts detected in the network. However, the last column in **Table 2** shows 4 countries with equal betweenness centrality of 0.02.

Please insert Figure 3 here

Please insert Table 2 here

Analysis of authors and co-cited authors

The results presented in this section represent the network of the main authors in the office workspace research. CiteSpace produced the visualization results of the co-authorship network as shown in **Figure 4.** There are 91 nodes and 71 links in the network representing the number of participating authors and pattern of collaboration among them respectively. The size of each node corresponds to the number of articles published by each respective author while the thickness of the link indicates the strength of collaboration among the authors. The node with the red circle in **Figure 4** represents the author with citation burst. The network detected only one author with citation burst which is Haynes BP with a burst strength of 5.61, spanning 2007 to 2011. Seven (7) authors were discovered with equal but low betweenness centrality of 0.01. The authors include; van der Voordt (Delft University of Technology), Heywood C (University of Melbourne), Touma AA (Qatar University),

Nenonen S (Tampere University of Technology), Habchi C (Universite Libanaise), Rytkönen E (Aalto University), and Jylhä T (Delft University of Technology). Several collaborations were observed among different research communities.

Please insert Figure 4 here

The top 10 most productive authors were identified in the network by CiteSpace according to the number of publications by each author. **Table 3** shows the top 10 most productive authors with their associated institutions and *h-index* for each author. The *h-index* is an author-level metric indicating both the productivity and citation impact of the publications of the authors.

Please insert Table 3 here

Author co-citation network

For the authors' co-citations analysis, CiteSpace generated a network of office workspace publications (**Figure 5**). The authors with the highest co-citation count were Nourse HO (58 citations) and Becker F (58 citations), followed by Gibson V (53 citations), Duffy F (53 citations), and Haynes BP (43 citations). The top 10 co-cited authors related to office workspace, based on betweenness centrality, are presented in **Table 4**.

Please insert Table 4 here

Please insert Figure 5 here

Figure 6 presents a visualization of the burst analysis of the cited authors in the dataset from 1990 to 2018, showing the top 20 bursting authors, based on burst weight. The figure in bold represents the strength of citation burst for each author while the red line denotes the length of the burst. For instance, the length (period) of burst for Kim J. is between 2016 and 2018 (2 years inclusive). It is worth emphasizing that burst detection reveals a rapid change in frequency, not entire frequency, hence, the burst signifies popularity rather than overall contributions of the cited author.

Please insert Figure 6 here

Analysis of journals and co-cited journals

This section focuses on the key publications of the domain by identifying the key journals based on their frequency, centrality and citation bursts. For this analysis, "Cited Journal" node in CiteSpace software was utilized, which generated a network of journal co-citations related to office workspace (**Figure 7**). With pathfinder pruning, the network produced 256

nodes and 672 links. Prominent journals in terms of frequency of publication above 100 include; “Energy and Building” (appearing in two different labels), followed by “Journal of Corporate Real Estate”, “Facilities”, “Journal of Real Estate Research”, and “Harvard Business Review”.

Please insert Figure 7 here

Table 5 presents details of the top 10 journals based on centrality. Of all 256 journals (nodes), Energy and Buildings has the highest value of centrality of 0.28. Other core journals in terms of centrality include; Journal of Business Ethics, Academy of Management Journal, Journal of Real Estate Literature and Environment and Behavior.

Please insert Table 5 here

Next is the analysis of how various journals have exhibited bursts, as shown in **Figure 8**. It can be seen that the “Building and Environment” journal has the largest burst with a burst strength of 24.54, beginning from 2015 and still bursting. Next is a closely related journal “Energy and Building” (burst = 23.77), followed by “Solar Energy” (burst = 14.62) in the same time frame. It is interesting to find that there are a lot of ongoing bursts in most of the journals.

Please insert Figure 8 here

Analysis of keywords (research hotspots)

Analysis of authors’ keyword and journal’s indexed terms (keyword plus) was conducted to determine the hotspots for office workspace field (Liang et al., 2018). To achieve this, search results of office workspace documents were imported into CiteSpace. The software then gathered all the keywords from the literature, performed various analyses including keyword frequency, citation bursts, and cluster analyses. A network of co-occurring office workspace-related keywords is shown in **Figure 9** with 519 nodes and 1509 links.

Please insert Figure 9 here

Table 6 reveals the top 20 co-occurring keywords with a high frequency of which “office building” has the highest score (frequency = 326), followed by “human” (frequency = 130). “Article” and “office space” occupied the third and fourth positions with the frequency of 123 and 99 respectively. The top keywords reflect the main hotspots of an office workspace.

Please insert Table 6 here

As shown in **Figure 10**, CiteSpace generated a timeline visualization of co-occurring keywords from 1990 to 2018 with each node representing cited keywords while the links denote keyword co-citation relationship. Lines that connect the nodes represent co-occurred links, while lines that connect clusters are central links (measured by betweenness of centrality). The colour pattern at the topmost part of **Figure 10** indicates a gradual change in time slices (years) across the study period, where the deep blue represents the beginning of the study (1990) and yellow colour on the far right end represents the end of the study period (2018). The colours of the links are set to reveal time slice that a connection between two keywords occurred for the first time, the colour of a node represents the time slice for a particular keyword, while colour a cluster label reflects the time slice for average year of the cluster member references' publication date (Chen et al., 2014). The highlighted nodes with cross sign (+) are the references with high betweenness centrality in the office workspace co-occurring keyword network, indicating important nodes that connect two clusters. In all, the network is grouped into 13 co-citation clusters, as defined by the log-likelihood ratio (LLR). The cluster labels were generated by index terms from their own citers and are arranged in ascending order according to the size of the clusters. Majority of the keywords that formed the clusters occurred between 2001 and 2018 as depicted by the colour variances. For instance, the largest cluster (#0 high anxious individual) is formed by references of keywords between 2002 and 2018. While the smallest cluster with a purple label (#12 European real estate research) is formed by a combination of keyword references between 2001 and 2009.

Please insert Figure 10 here

The largest 5 clusters are summarized in **Table 7** with "size" representing the number of keywords belonging to one cluster. "Mean Citee year" shows the average publication year of associated keywords. Frequency–inverse document frequency (TFIDF) and LLR are the CiteSpace algorithms used to generate the clusters. LLR is used as a standard in this study because it produces a unique result and better coverage (Jin, Ji, Li, & Yu, 2017). It can be seen that office workspace began to attract the attention of the research community in recent years.

Please insert Table 7 here

Figure 11 illustrates the top 25 keywords exhibiting the strongest citation bursts commencing from 2001 to 2018.

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Analysis of references co-citations (intellectual base)

Cited reference in CiteSpace is used to measure the intellectual base (Liang et al., 2018). Cited reference (document) co-citation network analyses those references that are cited by

1620 converted article records regarding office workspace. CiteSpace generated a network of references' co-citations, containing 874 nodes and 1998 links as shown in **Figure 12**. Each node (labeled with first author's last name and initials, and year of publication in parenthesis) symbolises a cited document while the link denotes the co-citation relationship between two documents. The circles (nodes) with purple rings indicate cited documents with high betweenness centrality (see details in **Table 8**).

Please insert Figure 12 here

Tables 8 lists the top 10 co-cited references based on citation frequencies related to office workspace. The most cited article (citation counts = 24) was published by Nourse and Roulac (1993). This implies that this document was cited by 24 out of the total article records extracted from Scopus and converted by CiteSpace.

Please insert Table 8 here

Table 9 presents a detailed analysis of the top 6 co-cited references based on centrality scores of office workspace-related studies. An interesting observation based on **Tables 8 and 9** is that the document (Nourse & Roulac, 1993) which has relatively highest frequency also recorded a higher centrality score.

Please insert Table 9 here

CiteSpace was used to visualize a timeline network for proper identification of the growth of the field. Here, the network is divided into 15 co-citation clusters. The largest 6 clusters are summarized in **Table 10**. The clusters were named by TFIDF and LLR test methods. Each cluster denotes a discrete specialty or thematic concentration (Chen et al., 2014). There are documents that exhibited citation "bursts" which indicate sudden interest in the office workspace domain,rflected in the number of citations.

Please insert Table 10 here

Discussion

Core subject areas, countries, and institutions (strengths)

In this study, three entities were used to describe core strengths about office workspace viz: the subject areas, countries, and institutions of the analysed articles. The benefit of identifying core strengths is that it reveals the relevance of a research topic to a particular subject category and the countries/institutions that are dominant in the research domain.

Out of all the identified areas (see **Table 1**), *"Engineering"* subject produced more publications than others, hence, it is the core subject area relevant to office workspace studies. The results reveal other variations of engineering field such as civil, environmental, and electrical and electronics also havinga significant number of publications. The results could connote the extent of the challenges faced in engineering field with regards to office workspace management. *"Construction & Building Technology"* ranked second with a frequency of 306 articles. *"Business & Economics"* occupied the third position. Generally, in a recent similar review study (Olawumi & Chan, 2018), "engineering" and "construction and building technology" were categorized as subject areas that are relevant to the built environment discipline. Since these two subject areas ranked first and second in this study, it can be deduced that workspace studies are most prominent in the built environment domain. The streams of research in the built environment started to grow when organization researchers started to increasingly pay attention to the workspace (De Paoli et al., 2017). More so, the creation of usable, effective and efficient workspace is majorly relying on the built environment profession (Alexander, 2006). Just as Facility Management involved different areas other than the built environment (Clifford, Elmualim, & Child, 2007), workspace management as well covers various areas including manufacturing, energy and fuel, service industries etc. (McGregor, 2000a). For instance, effective workspace management can reduce the following; fuel and energy used, lighting requirements in workspaces, and electricity cost (Lah, Mohammed, Abdullah, et al., 2015; Roth, 2006), which are related to energy and fuel, and electrical electronic engineering. In some organizations nowadays, facility managers are found responsible for energy management (Escrivá, Alcázar, & Álvarez, 2009). The idea of the workplace in this era of technology naturally comprises concepts such as the virtual workplace which is aided by computer science and information technology but naturally falls within the domain of facility management (Harmon-Vaughan, 1995). However, Yue and Liang (2011) suggested that different endeavors and domains should consider the best way to manage workspace for the benefit of their organizations. It has been established in the literature that the effects of new ways of working on office space usage and space demand across business firms were studied early (Harris, 2015), and this impact is clearly seen through the changes in the average workspace per person (Gibson, 2003b). The United States of America (USA) published more articles related to office workspace than other countries and the country recorded the highest betweenness centrality. This reveals the (advanced) level of office workspace research in the USA and significant influence the country has on the field of an office workspace. Based on the exhibited citation bursts, there are three countries that are currently attracting greater attention of the research community, China, India, and Italy. In terms of institutions, primarily, the research strength is concentrated at universities around the world. Among the top 10 institutions according to the size of publications and centrality score, the Delft University of Technology in the Netherlands is dominant in this research domain, with respect to the total contribution and influence. The entire analysis of the core strength can provide valuable information for potential researchers about the relevant subject area, leading countries, and institutions with high potential for collaboration in the office workspace domain.

Core authors

One good strength of the scientometric analysis is its ability to accurately link individual authors to their corresponding corpus of work. Based on analyses of authors and co-cited authors, the growth and paths of scientific research can be evaluated, and the authors' scholarly influence can be established using the number of individual author's publications, centrality, and the frequency of citations of published articles. In terms of a number of publications, the most productive authors include Ghali K (14 publications), Ghaddar N (12 publications) and Haynes BP (11 publications), having published more than 10 papers related to office workspace, hence, they are considered active professionals in this field. About 7 large cooperation networks were found among the authors, including (1) Ghali, Ghaddar, Habchi, Touma and Ouahrani, with research focus on cooling effect in office workspaces, (2) Beckers, van der Voordt, Dewulf, with research focus in facilities management, (3) Heywood, Kenley, Rytkönen and Sarasoja, with focus on corporate real estate field, (4) Andreatta, Pauli, Glotzbach-Schoon, and Mühlberger, with focus on human behaviour, (5) O'Brien, Gunay, Beausoleil-Morrison, and Gilani, with focus on modelling of office spaces, (6) Ali, McGreal, Adair, and Webb, with main studies on corporate real estate, and (7) Lai, Tsai, and Lin, with focus on fire disaster in office workplace. Other collaborations in the network involved two-author links. However, only a few authors attracted a very low centrality score (0.01), indicating a lack of influential central cluster among publishing authors.

According to author co-citation analysis, the authors with the highest co-citation count were Nourse HO (58 citations) and Becker F (58 citations), followed by Gibson V (53 citations), Duffy F (53 citations), and Haynes BP (43 citations). These are the authors that were cited by the articles extracted from the Scopus database and they are important authors in this domain. To recognize the main research direction in a particular discipline it is important to identify active contributors of a particular research domain (Yuan & Shen, 2011) so that interested researchers will be able to track and leverage on the contributions of previous researchers (Darko & Chan, 2016). Also, with the identification of active authors, interested researchers and practitioners can use the information to form useful collaborations for future research and development (Hong, Chan, Chan, & Yeung, 2011). Therefore, to provide useful information, researchers' contributions were analysed. Beside the purpose of collaboration, the information can also help interested researchers to easily contact the right author(s) for further information. Authors who published hot research articles are the ones who received citation bursts and they can be regarded as important authors/contributors in the field of an office workspace. Out of the top 20 cited authors with the strongest citation bursts, Jungsoo Kim of the University of Sydney, Australia, has the strongest citation burst of 10.395, beginning from 2016 and still bursting. Dr. Kim J. is a lecturer in the School of Architecture, Design, and Planning. His publication with the highest citations (Kim & De Dear, 2013) entitled "Workspace satisfaction: The privacy-communication trade-off in open-plan offices". The underlying contribution of this author has attracted and is still attracting the attention of the scientific community in the field of an office workspace. Potential researchers can pay attention to this author's works. Moreover, top co-cited authors based on betweenness centrality include Jennifer Veitch of

National Research Council of Canada (centrality score = 0.33), Virginia Gibson of University of Reading (centrality score = 0.30), Anca D. Galasiu of National Research Council of Canada (centrality score = 0.20), and Erik Sundström of Vinnova - Swedish Governmental Agency for Innovation Systems (centrality score = 0.19). The contributions from these authors have a great influence on other authors and they serve as pivotal links to various research communities. It was observed that authors with high publications and high citations did not have high centrality scores. This agrees with the finding by Zhao (2017), noting that only in rare cases would an author record both high citation counts and centrality scores.

Core journals

To reveal the core and active journals in this domain, a journal co-citation analysis was conducted. In terms of frequencies of citations of office workspace related studies, the first ranked is "Energy and Buildings" with citation count of 202. "Journal of Corporate Real Estate" is second, with citation counts of 174, followed by "Facilities" (publications = 147), "Journal of Real Estate Research" (publications = 132), "Energy and Buildings" (publications = 106), and "Harvard Business Review" (publications = 106). These are journals that have contributed significantly to office workspace studies, hence, they received more citations by researchers in this domain.

Out of the top 10 co-cited journals according to centrality, only 7 journals had a centrality greater than 0.10. They include "Energy and Buildings" (centrality score = 0.28), "Journal of Business Ethics" (centrality score = 0.21), "Academy of Management Journal" (centrality score = 0.18), "Journal of Real Estate Literature" (centrality score = 0.18), "Environment and Behavior" (centrality score = 0.17), "Journal of Real Estate and Research" (centrality score = 0.15), and "Journal of Corporate Real Estate" (centrality score = 0.13). It implies that papers published in these journals are of good quality and have a significant influence on office workspace studies. Meanwhile, the combination of citation frequency results and centrality scores revealed that 'Energy and Buildings', 'Journal of Real Estate and Research', and 'Journal of Corporate Real Estate' were highly cited and central journals in which researchers published their papers. "Facilities" is another journal that has published quality articles regarding office workspace in recent time. As posited by Lowry, Romans, and Curtis (2004), it is commonly assumed that high-quality journals do publish quality papers, and have more visibility and readership and more influence than low ranked journals. However, not all papers published in high-quality journals are of high quality and importance as some papers are with less impact to the society. Conversely, not every article that appears in a low ranked journal is of low quality as the fitness of a paper to intellectual paradigms and journal requirement are paramount to determine journal outlet for publication. This explains why some high impact journals in terms of impact factor may not be relevant in this study. It was also observed that the top 9 co-cited journals with the strongest citation burst are all related to energy and lighting in the building. These journals did not only have strongest citation bursts but are also still bursting, which implies the increased attention received for the office workspace field in the recent past.

Co-occurring keywords (Research hotspots)

A hotspot in a field can be identified by conducting trend analysis of a scientific issue that appears in a group of documents for a certain period of time, using the keywords in scientific publications (Liang et al., 2018). Hence, high-frequency keywords were used to establish the hotspots in the field of office workspace, using various parameters including; frequency, centrality, citation burst, and cluster analyses. The keyword with the highest frequency of occurrence was "office building" (frequency = 326), indicating that office workspace is closely related to an office building. The other high-frequency keywords such as human, article, and office space suggested that the topics of office workspace are concerned with human (workers) workspace, scientific articles, and office space arrangement. The keywords with high betweenness centrality scores include; United States (centrality = 0.27), Office building (centrality = 0.23), Workplace (centrality = 0.21), Architectural design (centrality = 0.21), and Building (centrality = 0.20). These are keywords that have significant influence in the developmental state of office workspace field and serve as connection platforms for several scientific topics. Keywords with strongest bursts can be used to determine hotspots in a specific period of time and can also reflect the emerging trends in a research field for that period (Zhang et al., 2011). The keyword with the highest burst strength (16.811) is "office space" with a period of burst from 2009 to 2012. Although the bursts last for a period of 3 years, the strength is very high, indicating that research on "office space" has recorded huge explosive growth within the specified period. The keyword with the longest period of burst from 2001 to 2010, is "leasing", with a low burst value of 3.449. Another interesting finding is the two keywords that started to burst in 2015 and are still bursting namely; "lighting" and "thermal comfort" with burst values of 6.620 and 5.041 respectively. These two keywords reflect the emerging trend in the office workspace field.

Moreover, the keywords were grouped into 13 clusters using the timeline view in CiteSpace. The top 5 largest clusters are shown in **Table 7**. Cluster with ID #0 (High-anxious individual) has the largest group size (69 member keywords), while cluster #4 (Corporate real estate) has the smallest size (37 member keywords). Out of the five clusters, Cluster ID #3 (Roller shade) is the most newly emerging trend encompassing 42 member keywords with an average year of publication of 2012. The topics covered by the 5 largest clusters mainly focused on the following: (#0) - anxiety, fear, threat and safety in office environment, (#1) – office space planning and design for medical practices, (#2) – office occupant comfort in naturally ventilated and mixed-mode spaces, (#3) – the influence of window shades on office space arrangements, and (#4) - corporate real estate practices in diverse regions. These largest clustered keywords (with the exception of #2 – occupant comfort) are the current hotspots for office workspace research. These hotspots can,, therefore, guide potential researchers to conduct studies in this field.

Document co-citation (Intellectual base)

In the bibliometric analysis, the research front in a field is usually recognised by the scientific knowledge evolution of discipline, and the references made in the frontier manuscripts represent the intellectual base of the field (Chen, 2006). By conducting document co-citation analysis (indicated as references in CiteSpace), the intellectual base in the field of office workspace was identified. The parameters used for the analysis of the references include citation frequency, citation burst, centrality, and cluster analysis. Nourse and Roulac (1993)'s document received the highest citation count of 24. Interestingly, this document has also recorded a higher centrality score (0.57) and the highest citation burst among others. This document, therefore, can be regarded as the main intellectual base for office workspace research. Nourse and Roulac (1993) examined how real estate strategy supports corporate strategy and vise versa. Some of the alternative strategies suggested in the document include minimization of occupancy costs, embracing flexibility (i.e. flexible space usage), and promoting human resources objectives (e.g. provision of an efficient environment that boost job satisfaction). Other references with higher citation frequencies topics such as collaborative and virtual offices (Duffy & Powell, 1997), smart working (Tagliaro & Ciaramella, 2016), work patterns and office productivity (Haynes, 2008), and visual comfort of building occupants (Wienold & Christoffersen, 2006). The scientific discourse of the references with higher centrality includes decision-making on business occupier relocation among small and large firms (Greenhalgh, 2008), decision-making process regarding corporate relocations (Nunnington & Haynes, 2011), and real estate decision and corporate strategies (Nourse & Roulac, 1993). These top 3 references with higher centrality focused on decision-making at various levels, and they represent central references that have greatly influenced office workspace research by connecting various relevant documents together. Four documents (references) received citation bursts viz: Nourse and Roulac (1993) (burst strength 5.29, spanning 2004-2014), Brennan, Chugh, and Kline (2002) (burst strength = 4.23, spanning 2008-2010), Manning and Roulac (2001) (burst strength =3.89, spanning 2003-2008), Becker and Steele (1995) (burst strength = 3.85, spanning 2003-2007). These are documents that have attracted the attention of the research community in different timelines. The most recent and strongest burst document is Nourse and Roulac (1993).

Furthermore, clustering analysis of the references was conducted, resulting in 15 clusters that help to explore the core topics in the intellectual base of an office workspace. Cluster #0 (short-distance relocation process) with 60 members, is the largest cluster, while the least cluster is #22 (office space occupation matter). Meanwhile, CiteSpace generated the top 6 largest clusters for references' co-citation with their mean year indicating the average age of the documents that formed each cluster. The most recent cluster is #3 (space energy demand) with the mean year of 2010. Consequently, the intellectual base in the field of office workspace contained many topics related to corporate real estate and most influential documents are published in real estate and facilities related journals, indicating that the field of office workspace is closely related to the field of corporate real estate and facilities management. This is consistency with the fact that "corporate real estate" and "facilities" are the disciplines that manage workplaces in practice. Since the clusters are formed mainly

by representative documents in the analysis, those documents can be followed by potential researchers to establish a new research field.

Implication of the study for the built environment profession

While this study focused on office workspace management, the findings hold useful implications for the built environment in general and facility management in particular, being a sector that encompasses multiple disciplines involving building, office assets, people, processes and technology, which enable effective functionality of the built facilities (Aishah Kamarazaly, Mbachu, & Phipps, 2013). The fundamental role of a Facility Manager involves maintaining, improving and adapting built infrastructure to enable the organizations to sustain their core activities. There is a global change in business operations that is influencing corporate real estate requirements, thereby generating spatial issues. Although many organizations have attempted to manage their workspace, their achievements seem low especially in the areas of cost reduction and user's satisfaction (Lah, Hamadan, & Awang, 2012). To address the workspace issues in the organizations world over, professionals within the built environment must embrace innovativeness to achieve efficient workplaces (Lindahl, 2004). Moreover, issues that are paramount to office workspace and demanding more attention of researchers in workspace research domain, have been revealed in this study.

One of the important research hotspots identified in this study is "office building" which interested researchers can explore from different perspectives such as sustainable office building (Feige, Wallbaum, Janser, & Windlinger, 2013; Juan, Gao, & Wang, 2010), multi-zone office building (Prívara et al., 2011), and intelligent office building (Preiser & Schramm, 2002). Different research issues from different office building types can be linked to workspace management in organizations. Workspace issues have been widely studied in different research arena with increasing concentration on employees' satisfaction. As the topic of workspace has become commonplace within the industry and academia, it is high time for researchers to pay more attention to creating clusters of research that focus on spatial issues that affect people including; fear, anxiety, threat, and safety, in relation to workspace in organizations. The work of Waber et al. (2014) which focused on the interface between workspace and people could be a useful reference for practitioners and researchers for future studies in this direction. Moreover, Haynes B.P. of Sheffield Hallam University is a proficient author that can be contacted in this regard. Design for comfortability (e.g. lighting and thermal comforts) in the workspace is another essential hotspot in this domain and the top 2 most productive authors (Ghali K and Ghaddar N) based on the findings from this study, are prominent researchers whose studies can be used for reference and can be contacted for collaboration.

Another promising future research focuses on office workspace design and management would be to explore the effect of integrating various technologies that can enable cost optimization, employees' satisfaction, and increased productivity in workplaces. For instance, radio frequency identification (RFID), a solution that could provide facilities managers with an automatic way of examining space in real time and over a wider area (e.g. Clifford et al., 2007; Lindkvist & Elmualim, 2009), could further be explored. Along the same line, it is imperative to explore the use of building information modeling (BIM)

in facilities management, particularly for appropriate workspace allocations (Wang, Wang, Wang, Yung, & Jun, 2013), as a dearth of research in this direction is identified in this study. Foreseeably, fusing such technologies into workspace management has some benefits such as; gaining more definitive knowledge of workspace, providing sufficient workspace for the employees to do their work, and enabling Facilities Managers to examine granular workspaces within offices from distance (Clifford et al., 2007). On the whole, by understanding burgeoning issues around office workspace and needs of an organization, facilities can be adapted to take advantage of technological advancement and employee characteristics in order to enhance productivity and foster employees' satisfaction. Consequently, the use of workspace management system will assist Facilities Managers in making the right decision in achieving effective office workspace.

Facility operators have a wide range of assets to maintain, ranging from building to office assets. The introduction of flexible workspace arrangement, characterized by multipurpose space, modern furniture, and smart office equipment, has improved the complex relationship between man and machine in the office. Moreover, regardless of the domain, the role of facility management (a profession in the built environment) in integrating this complex interface, is pivotal to the success of an organization (Finch, 2010). The advent of cutting-edge technology and its application in facility management will continue to see facility professionals work in diverse economic sectors (Teicholz, 2012), with the major responsibility of managing workspace for effectiveness and productivity enhancement in various organizations. Hence, facility managers must be kept abreast of strategies and tools necessary for efficient execution of their daily tasks especially, strategies that will ensure active workspaces as well as happy and productive employees. Fundamental to this is an appreciation of how the built environment can profoundly enhance workspace management in the current organizational settings.

Conclusion

Workspace management is more vital than ever in an increasingly diverse business organization. In the context of organizational workplace development, academic communities have been paying attention to the office workspace advancement. In this context, the authors performed a knowledge map analysis based on scientific literature obtained from the Scopus. Using 1620 bibliographic records of published office workspace related research, the study explored subject categories, countries, institutions, author co-citations, keyword co-occurrences, journal co-citations, and document co-citation networks to map and characterize the intellectual research base and hotspots of an office workspace. This study analysed and presented comprehensive knowledge maps of office workspace research, which provide valuable insights and relevant information for potential researchers to identify research trends, potential collaborators and their locations and intellectual base, and research hotspots. As commonly identified in similar studies, the authors also recognized that there are several potential limitations that may warrant cautions when interpreting or generalizing the findings from this study. First, the study was not set out to review the entire population of workspace management. Hence, the results presented herewith are exclusively based on the research articles related to office

workspaces that were published within the studied period. Second, the dataset used in this study were mainly sourced from the Scopus database, and other literature databases (e.g. Web of Science) were not considered. While the results may be highly credible and reliable, the use of a single database may have possibly excluded relevant studies. Besides, not all the articles obtained from Scopus were successfully converted by CitSpace for analysis. The same reason holds for the interpretation of research outcomes in this study. Hence, the unconverted references may influence the results if included in the analysis. For instance, there is a potential bias of underestimation for some countries and authors contributions to research in this domain. More literature databases could be explored in future research. However, the limitations should not undermine the usefulness of this study as it has contributed to the existing body of knowledge significantly. The findings presented herein will be valuable to interested researchers to gain insight into the future direction of office workspace research.

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Table 1: Number of publications distributed by top 10 subject areas

Publication counts	References	Ranking
480	Engineering (1991)	1
306	Construction & Building Technology, (1994)	2
255	Business & Economics, (1990)	3
204	Computer Science, (1995)	4
190	Engineering, Civil, (1994)	5
164	Management, (1992)	6
152	Energy & Fuels, (2002)	7
116	Engineering, Electrical & Electronic, (1992)	8
106	Engineering, Environmental, (2000)	9
70	Computer Science, Information Systems, (1996)	10

Table 2: Top 10 most productive institutions

Publication counts	Institution	Location	Centrality
27	Delft University of Technology	Netherlands	0.02
18	Purdue University	USA	-
16	American University of Beirut	Lebanon	-
14	The University of Melbourne	Australia	0.02
14	University of California, Berkeley	USA	0.02
13	Aalto University	Finland	-
12	Eindhoven University of Technology	Netherlands	-
12	National University of Singapore	Singapore	-
10	Polytechnic University of Milan	Italy	-
9	University of Sydney	Australia	0.02

Table 3: Top 10 most productive authors by numbers of publications

Counts	Authors	Country	Institution	h-index
14	Ghali K	Lebanon	American University of Beirut	22
12	Ghaddar N	Lebanon	American University of Beirut	25
11	Haynes BP	United Kingdom	Sheffield Hallam University	12
10	van der Voordt	Netherlands	Delft University of Technology	12
7	Heywood C	Australia	University of Melbourne	5
6	Andreatta M	Germany	Julius-Maximilians-Universitat Wurzburg	12
6	Pauli P	Germany	Julius-Maximilians-Universitat Wurzburg	46
5	Lindholm AL	Finland	Aalto University	7
4	Mühlberger A	Germany	Universitat Regensburg	32
4	Ouahrani D	Qatar	Qatar University	5

Table 4: Top 10 co-cited authors according to centrality

Centrality	Author	Institution
0.33	Veitch JA	National Research Council Canada
0.30	Gibson V	University of Reading
0.20	Galasiu AD	National Research Council Canada
0.19	Sundstrom E	VINNOVA (The Swedish Governmental Agency for Innovation Systems)
0.18	Duffy F	DEGW Plc, London
0.16	Danielsson CB	Stressforskningsinstitutet, Stockholms universitet
0.13	Tzempelikos A	Purdue University
0.13	Laing A	University of Waterloo
0.13	Leaman A	Building Use Studies Ltd, London
0.1	Oldham GR	Tulane University

Table 5: Top 10 co-cited journals according to centrality

Freq	Centrality	Journals	Impact factor
202	0.28	Energy and Buildings	4.457
6	0.21	Journal of Business Ethics	2.917
48	0.18	Academy of Management Journal	6.700
43	0.18	Journal of Real Estate Literature	0.530
57	0.17	Environment and Behavior	3.549
132	0.15	Journal of Real Estate Research	1.040
174	0.13	Journal of Corporate Real Estate	1.000
40	0.09	Journal of Property Research	-
88	0.08	Indoor Air	4.396
23	0.08	Journal of Urban Economics	2.292

Table 6: Top 20 co-occurring keywords according to frequency

S/N	Freq	Keyword	S/N	Keyword	Freq
1	326	Office building	11	Energy utilization	57
2	130	Human	12	United states	56
3	123	Article	13	Male	55
4	99	Office space	14	Office layout	54
5	84	Building	15	Energy conservation	53
6	83	Workplace	16	Lighting	50
7	75	Energy efficiency	17	Corporate real estate	49
8	67	Ventilation	18	Air conditioning	45
9	60	Real estate	18	Adult	42
10	58	Female	20	Architectural design	37

Table 7: Summary of the largest 5 clusters for co-occurring keywords

Cluster ID	Size	Label (TFIDF)	Label (LLR)	Mean (Citee Year)
#0	69	Effects	High-anxious individual	2009
#1	60	Case study	Medical practice	2006
#2	51	Effect	Occupant comfort	2008
#3	42	Influence	Roller shade	2012
#4	37	Corporate real estate	Corporate real estate portfolio	2007

Table 8: Top 10 co-cited references according to frequency

S/N	Document	Frequency
1	Nourse and Roulac (1993)	24
2	Duffy and Powell (1997)*	14
3	Spinuzzi (2012)	12
4	Haynes (2008)	11
5	Wienold and Christoffersen (2006)	10
6	Kim and De Dear (2013)	9
7	Reinhart (2004)	9
8	Galasiu and Veitch (2006)	8
9	Manning and Roulac (2001)	8
10	Zeckhauser and Silverman (1983)	8

* book erroneously extracted by Scopus

Table 9: Top 6 co-cited references according to centrality

S/N	Author	Centrality
1	Greenhalgh (2008)	0.59
2	Nunnington and Haynes (2011)	0.59
3	Nourse and Roulac (1993)	0.57
4	Ward (2005)*	0.44
5	Becker and Steele (1995)*	0.31
6	Singer, Bossink, and Vande Putte (2007)	0.31

* books erroneously extracted by Scopus

Table 10: Summary of the largest 6 clusters for references' co-citation.

Cluster ID	Size	Label (TFIDF)	Label (LLR)	Mean (Citee Year)
#0	60	City	Short-distance relocation process	2006
#1	46	Impact	Commercial real estate market	1997
#2	44	Well-being	Organizational identification	2000
#3	41	Case study	Spaces energy demand	2010
#4	40	Office space	Public space	2006
#5	39	Corporate real estate	Operational corporate real estate disposal	2000